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NATIONAL DAM SAFETY PROGRAM. MINERAL POINT NUMBER 2 DAM (MO 311--ETC(U)
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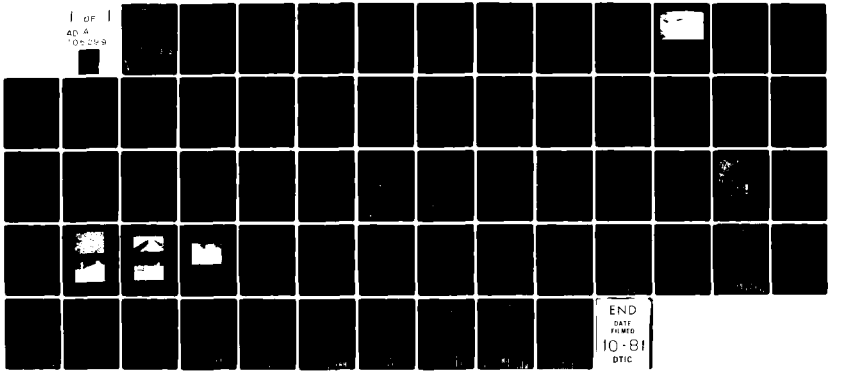

LEVEL II

AD A105299

MISSISSIPPI-KASKASKIA-ST. LOUIS BASIN

MINERAL POINT [illegible] DAM
WASHINGTON COUNTY, MISSOURI
MO 31158

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

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APRIL 1981

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18. SUPPLEMENTARY NOTES

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Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

SUBJECT: Mineral Point #2 Dam, Missouri Inventory No. 31158

This report presents the results of field inspection and evaluation of the Mineral Point #2 Dam. It was prepared under the National Program of Inspection of Non-Federal Dams.

SIGNED

SUBMITTED BY: _____ 9 JUL 1981
Chief, Engineering Division — Date

SIGNED

APPROVED BY: _____ 10 JUL 1981
Colonel, CE, Commanding — Date

MINERAL POINT #2 DAM

Washington County, Missouri

Missouri Inventory No. 31158

Phase I Inspection Report

National Dam Safety Program

Prepared by

Woodward-Clyde Consultants

Chicago, Illinois

Under Direction of

St Louis District, Corps of Engineers

for

Governor of Missouri

April 1981

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D. C., 20314. The purpose of a Phase I investigation is not to provide a complete evaluation of the safety of the structure nor to provide a guarantee on its future integrity. Rather the purpose of the program is to identify potentially hazardous conditions to the extent they can be identified by a visual examination. The assessment of the general condition of the dam is based upon available data (if any) and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies. In view of the limited nature of the Phase I studies no assurance can be given that all deficiencies have been identified.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with any data which may be available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action removes the normal load on the structure, as well as the reservoir head along with seepage pressures, and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, so that corrective action can be taken. Likewise continued care and maintenance are necessary to minimize the possibility of development of unsafe conditions.

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Mineral Point #2 Dam
State Located	Missouri
County Located	Washington
Stream	Unnamed Tributary of Mill Creek
Date of Inspection	26 February 1981

The Mineral Point #2 Dam Missouri Inventory Number 31158 was inspected by Richard Berggreen (engineering geologist), Pierre Mallard (geotechnical engineer), Jean-Yves Perez (geotechnical engineer), and Sean Tseng (hydrologist). The dam is an abandoned barite tailings dam.

The dam inspection was made following the guidelines presented in the "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed by the Chief of Engineers, US Army, Washington, DC, with the help of federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines represent a consensus of the engineering profession. They are intended to provide for an expeditious identification, based on available data and a visual inspection, of those dams which may pose hazards to human life or property. In view of the limited scope of the study, no assurance can be given that all deficiencies have been identified.

This dam is classified as intermediate size due to its 64 ft height and storage capacity of 322 ac-ft (155 ac-ft tailings, the remainder is water). The intermediate size dam classification includes dams between 40 and 100 ft in height, or having storage capacities between 1000 and 50,000 ac-ft. Based on the intermediate size classification of this dam, 100 percent PMF is the recommended spillway design flood.

The St Louis District (SLD), Corps of Engineers has classified this dam as having a high hazard potential; we concur with this classification. The SLD estimated damage zone length extends approximately 10 mi downstream. Located within this zone are the Missouri-Pacific Railroad, Missouri Highway 47, and several occupied dwellings.

The inspection and evaluation indicate that the dam is in generally good condition. Specific deficiencies noted are the steep downstream slope and lack of maintenance and periodic inspections. Also deemed as a deficiency is the lack of any stability or seepage analyses as per the recommended guidelines.

Hydrologic/hydraulic analyses indicate that the dam will not be overtopped by a hydrologic event which produces the Probable Maximum Flood (PMF). These analysis also indicate that the dam will not be overtopped by the 1 percent probability-of-occurrence flood (100 yr flood). In fact, the reservoir has enough available storage capacity to store the PMF without inducing any spillway outflow. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

The following remedial measures are recommended for Mineral Point #2 Dam.

1. Perform seepage and stability analyses as required by the "Recommended Guidelines for Safety Inspections of Dams." The stability analysis should be performed for appropriate loading conditions, including seismic loads. In addition, these analyses should include both an evaluation of the chat embankment and the flow susceptibility of the impounded fine tailings.

2. A program of periodic inspections should be implemented for the dam and appurtenant structures. These inspections should report any maintenance recommendations. Records of the inspections, recommended and performed maintenance should be kept.

It is recommended the owner takes action on these recommendations as soon as practical. All remedial measures should be performed under the guidance of an engineer experienced in the design and construction of dams.

WOODWARD-CLYDE CONSULTANTS

Richard G. Berggreen
Registered Geologist, No 3572, CA

Jean-Yves Perez, PE, No. 62-34675, IL
Vice President

OVERVIEW

MINERAL POINT #2 DAM

MISSOURI INVENTORY NUMBER 31158

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
MINERAL POINT #2 DAM, MISSOURI INVENTORY NO. 31158
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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
MINERAL POINT #2 DAM, MISSOURI INVENTORY NO. 31158

SECTION 1
PROJECT INFORMATION

1.1 General

a. **Authority.** The National Dam Inspection Act, Public Law 92-367, provides for a national inventory and inspection of dams throughout the United States. Pursuant to the above, an inspection was conducted of Mineral Point #2 Dam, Missouri Inventory Number 31158.

b. **Purpose of inspection.** "The primary purpose of the Phase I investigation program is to identify expeditiously those dams which may pose hazards to human life or property... The Phase I investigation will develop an assessment of the general condition with respect to safety of the project based upon available data and a visual inspection, determine any need for emergency measures and conclude if additional studies, investigations and analyses are necessary and warranted" (Chapter 3, "Recommended Guidelines for Safety Inspection of Dams").

c. **Evaluation criteria.** The criteria used to evaluate the dam were established in the "Recommended Guidelines for Safety Inspection of Dams," and Engineering Regulation No. 1110-2-106 and Engineering Circular No. 1110-2-188, "Engineering and Design National Program for Inspection of Non-Federal Dams," prepared by the Office of Chief of Engineers, Department of the Army; and "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams," prepared by the St Louis District (SLD), Corps of Engineers. These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 Description of Project

a. **Description of dam and appurtenances.** Mineral Point #2 Dam is an abandoned barite tailings dam. Although its construction and usage is typical of other barite tailings dams in the area, it is not typical of dams constructed for the impoundment of water. The unique nature of these tailings dams has a significant impact on their evaluation. A brief description of the construction procedure and usage of Missouri tailings dams is necessary to highlight the differences between these dams and conventional water-retaining dams.

At the start of a barite mining operation in this area, a 20 to 30-ft high starter dam is usually first constructed across a natural stream channel. Generally the streams are intermittent so that construction is carried out in the dry. Trees and other vegetation are removed from the dam site and a cutoff trench is often made to shallow bedrock. Locally obtained earth, usually a gravelly clay, is then placed to form the embankment. Compaction is limited to that provided by the equipment.

The barite ore is contained within the residual gravelly clay, which is mined with earth-moving equipment. At the processing plant, the ore is washed to loosen and remove the soil. The water is obtained from the reservoir area behind the dam. The soil-laden wash water and water from other steps in the process is then discharged into the reservoir. There the soil is deposited by sedimentation and the water recycled. Another step in the process removes the broken gravel-sized waste which is called "chat".

As the level of the fine tailings increases, the dam is raised. The usual method involves the dumping of chat on the dam crest. Then the chat is spread over the crest so that a relatively constant crest width is maintained as the dam is raised. Generally the crest centerline location is also maintained. However, the crest centerline location may migrate upstream if there is insufficient chat available and downstream if an excessive quantity of chat is available. The latter is uncommon because it is indicative of a poor ore deposit.

This method of construction results in slopes which are close to the natural angle of repose for the chat. They can be considered to be near a state of incipient failure.

A large quantity of water is required for a processing operation, on the order of 2000 to 5000 gal/min. Thus it has been the operators' practice to construct the dam so that all inflow to the reservoir is recycled in order to have sufficient water for the operation. The result is that formal spillways or regulating outlets are generally not constructed. In most cases a low point on or near the dam is provided, should the storage capacity be exceeded.

The fine tailings typically fill more than 80 percent of the total storage volume. This results from the operator's practice of maintaining only a 2 to 5 ft elevation differential between the level of the impounded tailings and the dam crest. The differential is usually greater further away from the discharge point and also typically further away from the dam.

The geotechnical characteristics of the fine tailings are somewhat similar to recent lacustrine clay deposits. Where the tailings have been continuously submerged, they have a very soft consistency and high water contents. When evaporation causes the water level to recede and the tailings are exposed, a stiff crust forms as the tailings dry out. Below the crust, the tailings retain their soft consistency for long periods of time. The consistency is very gradually modified by a slow process of consolidation.

Mineral Point #2 Dam is representative of barite tailings dams. It is presently abandoned. The embankment was constructed with chat. The downstream slope is very steep and the upstream slope is covered by the fine tailings. The spillway is located near the south-west end of the dam (near the right abutment) and is in natural soil. The downstream channel is a gully also in natural soil. There are no regulating outlets.

b. **Location.** The dam is in a tributary valley to Mill Creek, about 0.5 mi north of the town of Mineral Point, Washington County, Missouri. The dam is in Sec 5, T37N, R3E, about 0.8 mi southeast of Missouri Highway E on the USGS Mineral Point 7.5-minute quandrangle map.

c. **Size classification.** The dam is classified as intermediate size due to its 64 ft height. The reservoir has a storage capacity of 322 ac-ft (155 ac-ft tailings, remainder water). The intermediate size classification includes dams between 40 and 100 ft in height or having storage capacities between 1000 and 50,000 ac-ft, whichever gives the larger classification.

d. **Hazard classification.** The St Louis District, Corps of Engineers, has classified this dam as having a high hazard potential; we concur with this classification. The SLD estimated damage zone length extends approximately 10 mi downstream. Located within this zone are the Missouri-Pacific Railroad, Missouri Highway 47, and several occupied dwellings.

e. **Ownership.** The dam is reportedly owned by Charles Pfizer & Co, Inc, 2001 Lynch Ave, East St Louis, Illinois 62201. Correspondence should be sent to the attention of Mr William A Wilkenson, Plant Manager.

f. **Purpose of dam.** The dam was constructed to impound fine barite tailings and barite mill process water. It is currently abandoned.

g. **Design and construction history.** No records of the design or construction were found and probably do not exist. According to Mr R. Griffey, a local Pfizer superintendent, the dam was started in 1960. It was continually raised until operations ceased in 1963. Construction procedures were likely typical of barite tailings dams in the area, as described in Section 1.2a.

h. **Normal operating procedures.** At the present time, mining activities have ceased. There are no operating procedures in effect.

1.3 Pertinent Data

a. **Drainage area.** 0.04 mi^2

b. **Discharge at damsite.**

Maximum known flood at damsite	Unknown
Warm water outlet at pool elevation	N/A
Diversion tunnel low pool outlet at pool elevation	N/A
Diversion tunnel outlet at pool elevation	N/A
Gated spillway capacity at pool elevation	N/A
Gated spillway capacity at maximum pool elevation	N/A
Ungated spillway capacity at maximum pool elevation	5 ft^3/sec
Total spillway capacity at maximum pool elevation	5 ft^3/sec

c. **Elevation (ft above MSL).**

Top of dam	914.5 to 924.2
Maximum pool-design surcharge	N/A
Full flood control pool	N/A
Recreation pool	N/A
Spillway crest (gated)	N/A
Upstream portal invert diversion tunnel	N/A
Downstream portal invert diversion tunnel	N/A
Maximum tailwater	Unknown
Toe of dam at maximum section	852.0

d. **Reservoir.**

Length of maximum pool	1000 ft
Length of recreation pool	N/A
Length of flood control pool	N/A

e. **Storage (acre-ft).**

Recreation pool	N/A
Flood control pool	N/A
Design surcharge	N/A
Top of dam	322 (155 ac-ft tailings, remainder water)

f. **Reservoir surface (acres).**

Top of dam	19
Maximum pool	19
Flood-control pool	N/A
Recreation pool	N/A
Spillway crest	18

g. **Dam.**

Type	Barite tailings
Length	1730 ft
Height	64 ft
Top width	12.6 to 17.7 ft
Side slopes	Downstream, 1.4-1.6(H) to1(V) Upstream, unknown
Zoning	Unknown (probably none)
Impervious core	Unknown (probably none)
Cutoff	Unknown (probably trench to shallow rock)
Grout curtain	Unknown (probably none)

h. **Diversion and regulating tunnel.**

Type	None
Length	N/A
Closure	N/A
Access	N/A
Regulating facilities	N/A

i. **Spillway.**

Type	Trapezoidal shape, uncontrolled, unlined earth, 1.6 ft deep
Length of weir	10.4 ft (at el 914.3)
Crest elevation	914.3 ft
Gates	None
Downstream channel	Unlined earth

j. **Regulating outlets.** None

SECTION 2
ENGINEERING DATA

2.1 Design

No design drawings or data were found.

2.2 Construction

No construction records or data were found.

2.3 Operation

No records were found for reservoir water surface elevation or spillway discharge history. Dam is currently abandoned.

2.4 Evaluation

a. **Availability.** No data were available for review.

b. **Adequacy.** Insufficient data were available to determine the adequacy of the design.

Seepage and stability analyses comparable to the requirements of the recommended guidelines were not available, which is considered a deficiency. These analyses should be performed by an engineer experienced in the design and construction of dams. Further, these seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. **Validity.** Not applicable.

2.5 Project Geology

The dam site lies on the northern flank of the Ozark structural dome. The regional dip is to the north. The bedrock in the area is mapped as Cambrian age Eminence and Potosi Dolomite formations on the Geologic Map of Missouri (Fig. 4). The Potosi Dolomite is a light gray, medium- to fine-grained dolomite which typically contains an abundance of quartz druse characteristic of chert bearing formations. The Eminence Dolomite conformably overlies the Potosi Dolomite, is similar in appearance, but contains less quartz and chert.

The soil at the dam site is a dark red-brown, plastic residual clay (CH), characteristically developed on the Potosi Dolomite. It is locally overlain by a 1 to 5 ft thick silty loess soil (ML). The area is mapped on the Missouri General Soils Map as Union-Goss-Gasconade-Peridge Association.

The Cabanne fault, an east-west trending branch of the Big River fault system, is mapped approximately 1/2 mi south of the dam. The fault is mapped as north side down and is within the Potosi and Eminence Dolomite formations at the surface. The Aptus fault, a northwest-southeast trending branch of the Big River fault system is mapped approximately 4-1/2 mi west of the site. The Aptus fault is mapped as southwest side down, and is mapped within the Potosi and Eminence Dolomite formations at the surface. The faults are likely of Paleozoic age and are not considered to be in a seismically active region. These faults like most others in the Ozark area are not considered active and are not considered to pose a significant threat to the safety of the dam.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. **General.** A visual inspection was made of Mineral Point #2 Dam on 26 February 1981 without an owner's representative present. This inspection indicated the dam is in generally good condition. The owner's representative, Mr Robert Griffey, met with the inspection team after the inspection was completed and provided additional information during the interview.

b. **Dam.** The embankment is composed of coarse tailings or "chat" (Photo 1). This material, gravel, sandy gravel and sand (GW, SW), is cohesionless and permeable and would likely be severely and rapidly eroded if the dam were significantly overtopped.

The downstream slope is at 1.4-1.6 (H) to 1(V), which is near the natural angle of repose for the "chat." Piles of "chat" have been dumped on the crest and along the slopes during the construction process resulting in locally irregular shapes of the slopes and crest (Photos 2 and 3).

The vertical and horizontal alignment of the dam crest do not appear to have been disturbed as a result of deformation. No evidence of detrimental settlement, cracking, sinkholes or animal burrows were found during the inspection.

No seepage was noted at the time of the inspection. Although a wet area was located at the downstream toe of the dam near the maximum section, evidence of past water is probably due to poor surface drainage rather than seepage through the dam. Reservoir was nearly dry at the time of visual inspection.

No trees are growing on the downstream face of the dam, except for one on the downstream slope near the maximum section (Photo 2). Bedrock is

exposed in the downstream channel near maximum section which means that the starter dam was probably built on rock.

c. **Appurtenant structures.** The spillway is located at the right abutment of the dam through a mined area (Photo 4). The spillway is an unlined channel in natural soil which is moderately erodible. The irregular topography in the reservoir area upstream of the spillway as well as bushes growing at the spillway entrance could partially retard discharge through the spillway. There was no evidence of past flow through the spillway.

d. **Reservoir area.** Approximately 90 percent of the reservoir area was above the water level at the time of inspection. The drainage area around the reservoir is rather small (0.04 mi^2) (see Overview Photo). The exposed reservoir area was covered with brushy growth extending to the dam crest. The dense vegetation indicates erosion of the upstream face of the dam will not likely be a significant problem.

Although the impounded tailings level is close to the crest level along the embankment, there is 10 to 15 ft of freeboard between the center of the reservoir and the crest of the dam. The fine tailings impounded in the reservoir, primarily silt and clay, are relatively impervious; they appear to have been draglined along the upstream face of the embankment to seal the dam. Slopes surrounding the reservoir are rather flat and showed no signs of instability at the time of the visual inspection.

e. **Downstream channel.** The downstream channel is an unlined gully which discharges the spillway overflow away from the embankment (Photo 5). There is some vegetation in the channel but it does not appear sufficient to obstruct flow during flooding because the slope is rather steep.

3.2 Evaluation

The results of our visual inspection indicate the embankment and appurtenant structures are in generally good condition. No evidence of sinkhole development, depressions, cracking, animal burrows, or significant erosion was noted during the visual inspection. No extensive seepage through the dam was noted.

The downstream slope is very steep, and although no slides were observed, the slopes are considered to be close to failure.

The erodibility of the spillway area is not considered to be detrimental to the safety of this dam because of its location and direction of discharge. The spillway does not pass through the main embankment but passes through a natural spur. Erosion of the spillway and downstream channel would increase their present discharge capacity but would not likely cause failure of the main embankment.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures

The dam is currently abandoned. So far as could be determined there are no operational procedures for this dam. The water level is controlled by the crest of the spillway.

4.2 Maintenance of Dam

No records of maintenance on this facility were available.

4.3 Maintenance of Operating Facilities

There are no operating facilities at this dam.

4.4 Description of Any Warning System in Effect

The inspection did not identify any warning system in effect at this facility.

4.5 Evaluation

There are apparently no maintenance or operational procedures in effect. The lack of regular maintenance and periodic inspections is considered a deficiency.

The feasibility of a practical warning system at this particular facility is questionable but should be evaluated to determine whether or not a satisfactory system can be developed to alert downstream residents, railroad and highway officials should potentially hazardous conditions develop during periods of heavy precipitation.

SECTION 5
HYDROLOGY/HYDRAULICS

5.1 Evaluation of Features

a. **Design data.** No hydrologic or hydraulic design data were available for evaluation of this dam or reservoir; however, dimensions of the dam were surveyed. The survey data were supplied by James F. McCaul, III and Associates of Potosi, Missouri. Other relevant data were measured during the visual inspection or estimated from topographic mapping. The map used in the analyses was the USGS Mineral Point, Missouri 7.5-minute quadrangle map (1958).

b. **Experience data.** No recorded rainfall, runoff, discharge or pool stage historical data were found for this reservoir.

c. **Visual observations.** No conditions were noted which could lead to a reduced downstream channel capacity during a flood occurrence. However, there are obstacles in the spillway and their effect has been taken into account in the analysis. Other observations regarding the spillway and downstream channel are presented in Section 3.

The reservoir area represents about 40 percent of the total drainage area of 0.04 mi^2.

d. **Overtopping potential.** One of the primary considerations in the evaluation of Mineral Point No. 2 Dam is the assessment of the potential for overtopping and consequent failure by erosion of the dam. The lowest portion of the dam which is near the south end of the embankment was considered to be the top of the dam for the purpose of determining overtopping potential.

Hydrologic analysis of this dam for the 1 and 10 percent probability-of-occurrence and Probable Maximum Flood (PMF) were all based on initial water surface elevations equal to the water level elevation at the time of the survey. A storm of 25 percent and 50 percent PMF, respectively, preceded the

50 percent PMF and PMF storms by four days. The results of the analyses indicate that the PMF will not be able to overtop the dam. In fact, no outflow will occur through the spillway as the available storage in the reservoir is sufficient to store the PMF. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic or hydrologic conditions that are reasonably possible in the region. The analyses also indicate that the reservoir will store the 1 percent probability-of-occurrence (100-year) flood event without inducing flow in the spillway or overtopping the dam. The 1 percent probability-of-occurrence flood event is the precipitation event that has a 1 percent chance of occurring in any year, or once in every 100 years.

The following overtopping data for various flood events were computed for the dam.

Precipitation Event	Maximum Reservoir Elevation, ft (MSL)	Maximum Depth of Overtopping, ft	Maximum Outflow, ft^3/sec	Duration of Overtopping, hrs
1% PMF	904.1	0	0	0
50% PMF	907.3	0	0	0
100% PMF	911.0	0	0	0

Input data and output summaries for the hydrologic and hydraulic analyses are presented in Appendix B. Complete copies of the HEC-1 computer printout are available in the project files.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. **Visual observations.** Features identified during the visual inspection which adversely affect the structural stability of this dam are reported in Section 3. Of primary importance is the steepness of the downstream face. This slope appears to be at the natural angle of repose for this material, and therefore is in a state close to incipient failure with safety factors close to one.

Cracking, horizontal or vertical displacement of the dam crest, detrimental settlement, slides, depressions or other signs of instability were not observed.

b. **Design and construction data.** No design or construction data relating to the structural stability of the dam were found. Construction was likely typical of barite tailings dams in the area, as described in Section 1.2a.

c. **Operating records.** No operating records were found. Seepage and stability analyses comparable to the requirements of the guidelines are not on record. This is a deficiency which should be corrected to meet recommended guidelines.

d. **Post construction changes.** The dam and reservoir have been abandoned. The barite mill at the site has been dismantled and the owner did not indicate any current intention to reactivate the operations.

The lack of drawings or construction reports precludes identification of post construction changes. However, no obvious changes were observed or reported.

e. **Seismic stability.** The dam is in Seismic Zone 2, to which the guidelines assign a moderate damage potential. Since no static stability analysis is available for review, the seismic stability cannot be evaluated. However, as the tailings are fine-grained, saturated materials and the dam is of loose, granular material, substantial deformation or failure could occur in the event of a severe seismic event.

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. **Safety.** Based on the findings of the visual inspection, the Mineral Point #2 Dam is judged to be in generally good condition. Specific deficiencies noted were the steep downstream slope, lack of maintenance and lack of periodic inspections. Potential obstructions in the upstream part of the spillway and the discharge channel are of no consequence as the reservoir has sufficient capacity to store the design floods and the spillway is not likely to carry any flood flow.

Stability and seepage analyses as per the "Recommended Guidelines for the Safety Inspections of Dams" were not on record, which is considered a deficiency.

As a consequence of the widely-used construction procedure, the downstream slopes of tailings dams such as this one are placed at the angle of natural repose for the chat material. This results in slopes that are very steep and in a state close to incipient failure with safety factors close to one. This situation is subject to some gradual improvement with time as consolidation and/or dessication of the fine-grained tailings results in an increase in strength and a resultant decrease in the lateral pressures on the embankment.

The slopes placed at the angle of natural repose will only remain stable if they are protected against potential harmful changes, among which are:

1. Overtopping by water,

2. Higher pore pressures (or seepage forces),

3. Undercutting of the toe of the slope by erosion or mining activity,

4. Increase in the height of the embankment,

5. Harmful effects of vegetation (particularly tree roots),

6. Liquefaction (such as may result from a seismic event).

Some of these changes are subject to control by owners and must receive careful attention under the guidance of an engineer experienced in the design and construction of earth dams in order to maintain stable and safe dam embankments. The sixth influence represents a risk the magnitude of which is not well understood without further study.

b. **Adequacy of information.** The lack of stability and seepage analyses for the dam as recommended in the guidelines is considered a deficiency.

c. **Urgency.** The deficiencies described in this report could affect the safety of the dam. Corrective actions should be initiated as soon as practical.

d. **Necessity for Phase II.** In accordance with the "Recommended Guidelines for Safety Inspections of Dams," the subject investigation was a minimum study. This study revealed that additional in-depth investigations are needed to complete the assessment of the safety of the dam. Those investigations which should be performed as soon as practical are described in Section 7.2b. It is our understanding from discussions with the St Louis District that any additional investigations are the responsibility of the owner.

7.2 Remedial Measures

a. **Alternatives.** There are several general options which may be selected to reduce the possibility or harmful consequences of dam failure at this dam. Some of these options are listed below.

1. Remove the dam, or breach it to prevent storage of water.

2. Purchase downstream land that would be adversely impacted by dam failure and restrict human occupancy.

3. Provide a highly reliable flood warning system (generally does not prevent damage but diminishes chances for loss of life).

b. **Recommendations.** It is recommended that seepage and stability analyses be performed as soon as practical as required by the "Recommended Guidelines for Safety Inspections of Dams." The stability analyses should be performed for appropriate loading conditions, including seismic loads. In addition, these analyses should include both an evaluation of the chat embankment and the flow susceptibility of the impounded fine tailings.

c. **O & M procedures.** A program of periodic inspections should be implemented for the dam and appurtenant structures as soon as practical. The inspection should report maintenance recommendations. Records of the inspections and maintenance should be kept.

All remedial measures should be performed under the guidance of an engineer experienced in the design and construction of dams.

REFERENCES

Allgood, F. P., and Persinger, I., D., 1979, Missouri General Soil Map and Soil Association Descriptions: US Department of Agriculture, Soil Conservation Service and Missouri Agricultural Experiment Station.

Department of the Army, Office of the Chief of Engineers, 1977, EC 1110-2-188, Engineering and Design National Program of Inspection of Non-Federal Dams.

Department of the Army, Office of the Chief of Engineers, 1979, ER 1110-2-106, Engineering and Design National Program of Inspection of Non-Federal Dams.

Hydrologic Engineering Center, US Army Corps of Engineers, 1978, Flood Hydrograph Package (HEC-1) Users Manual for Dam Safety Investigations.

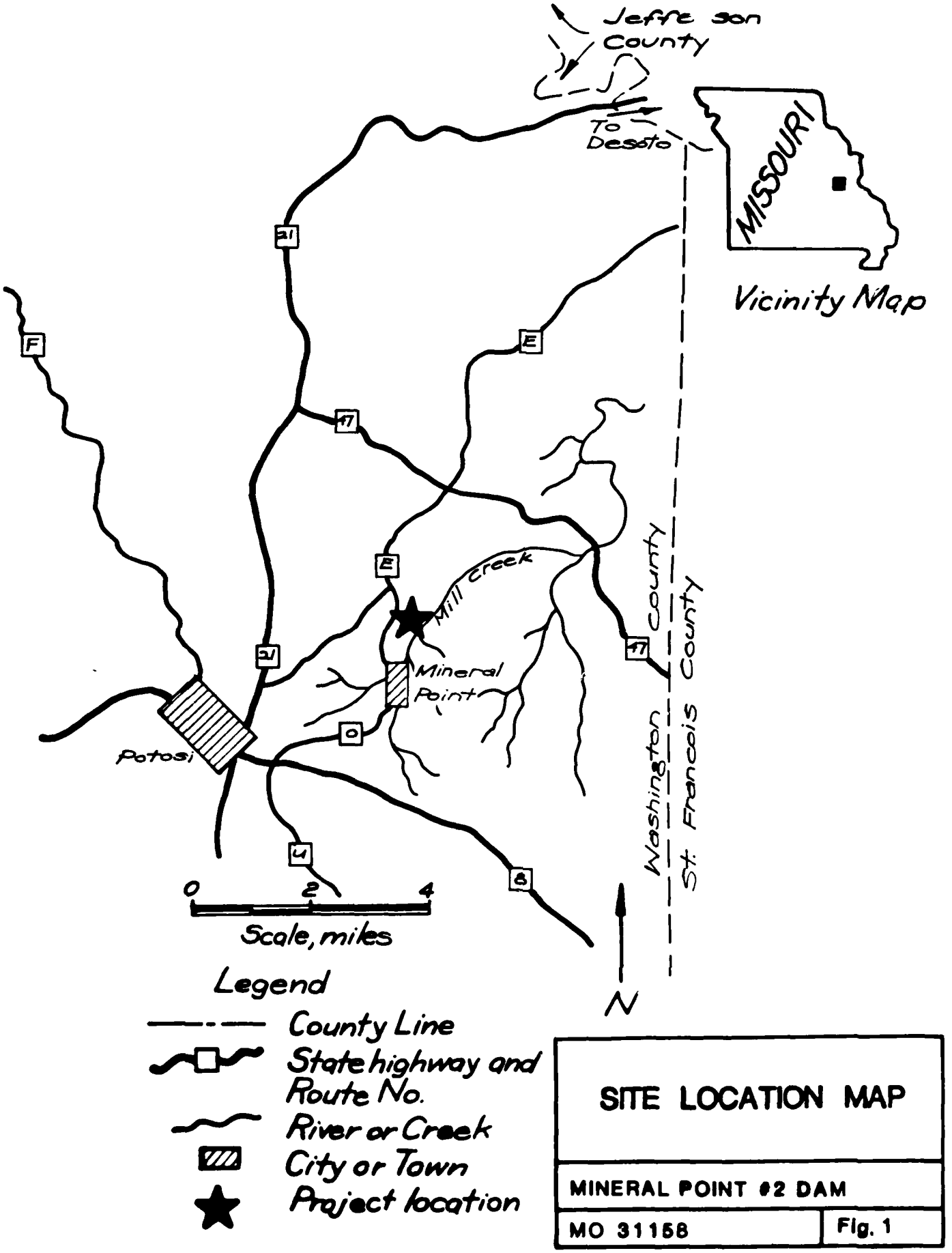
McCracken, M. H., 1971, Structural Features Map of Missouri: Missouri Geological Survey, scale 1:500,000.

Missouri Geological Survey, 1979, Geologic Map of Missouri: Missouri Geological Survey, scale 1:500,000.

St Louis District, US Army Corps of Engineers, 1979, Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams.

US Department of Agriculture, Soil Conservation Service, 1971, Hydrology: National Engineering Handbook, Section 4.

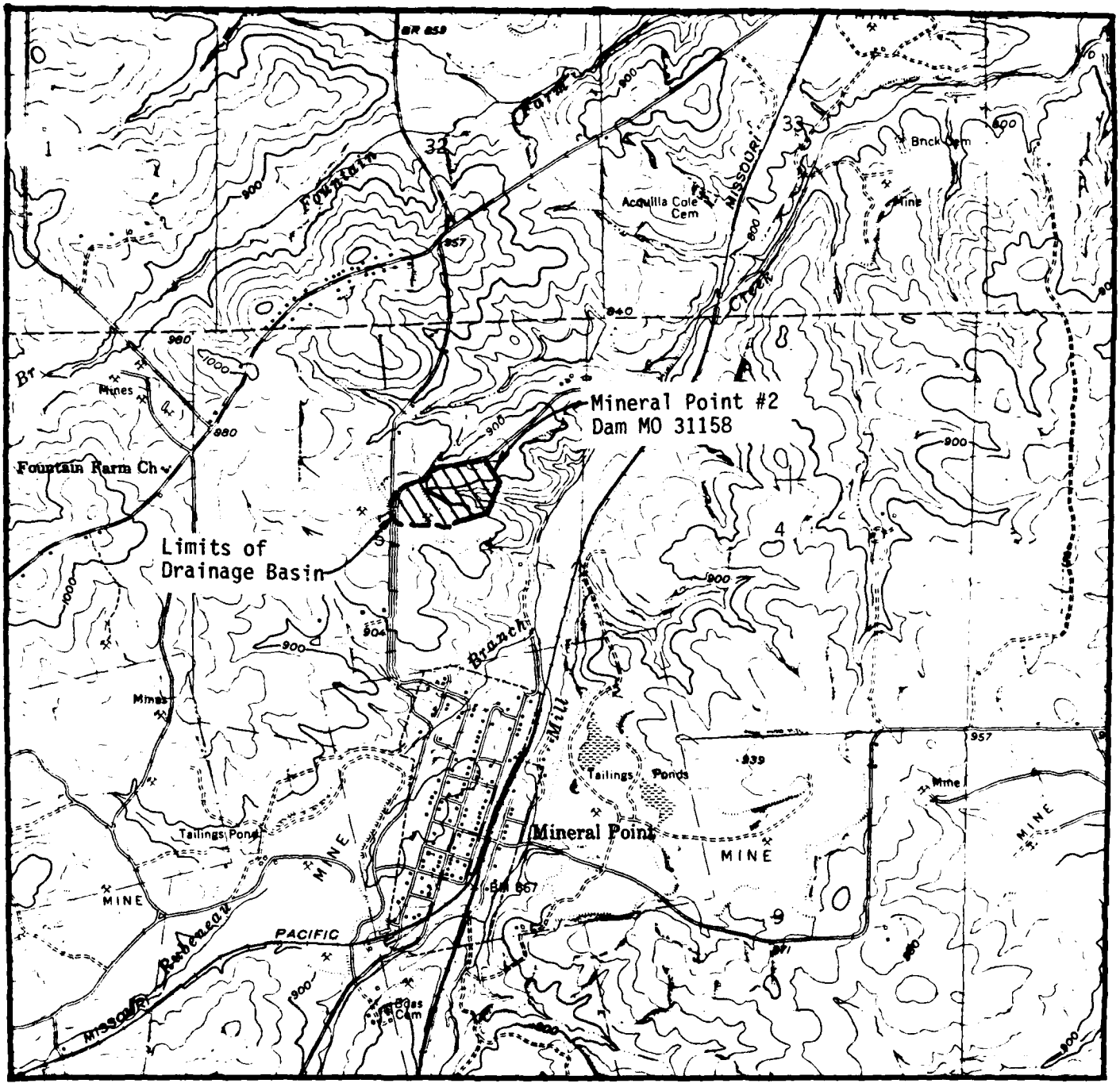
US Department of Commerce, US Weather Bureau, 1956, Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24 and 48 Hours, Hydrometeorological Report No. 33.



SITE LOCATION MAP

MINERAL POINT #2 DAM

MO 31158 | Fig. 1



North

0 2000 4000

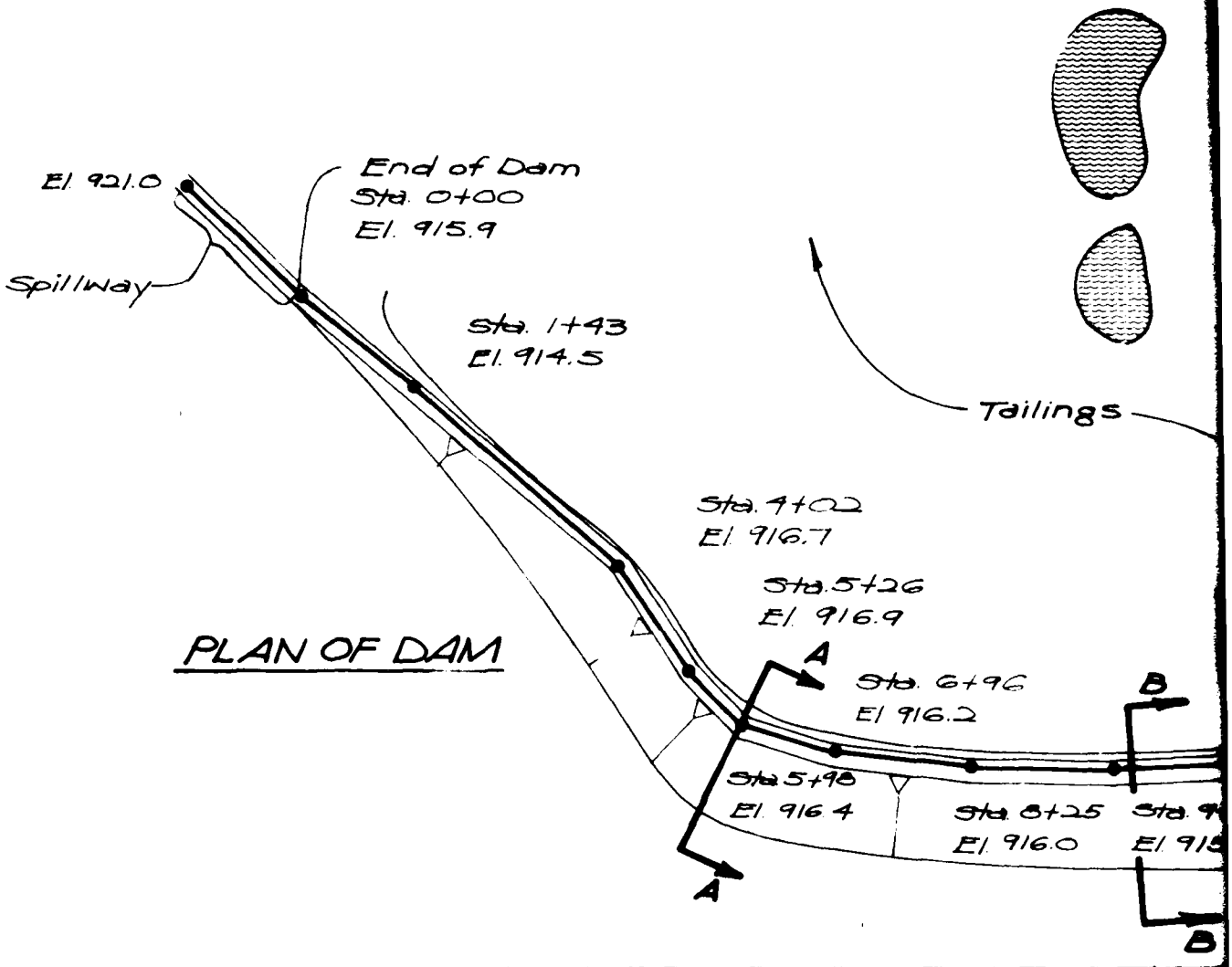
Scale, feet

Notes:
1. Topography from USGS Mineral Point 7.5-minute quadrangle map (1958).

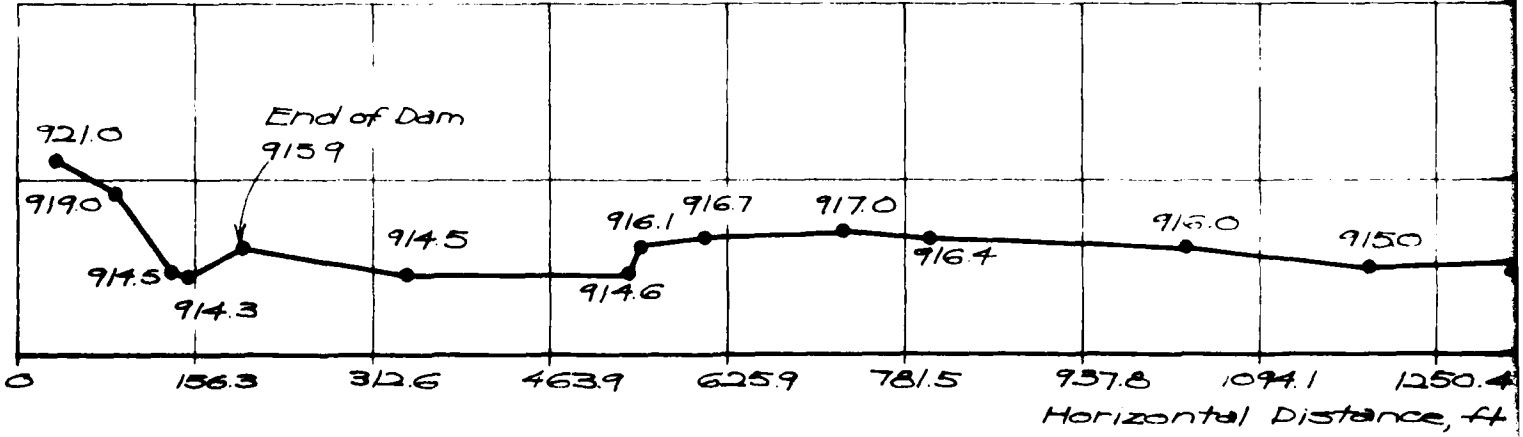
DRAINAGE BASIN AND SITE TOPOGRAPHY

MINERAL POINT #2 DAM

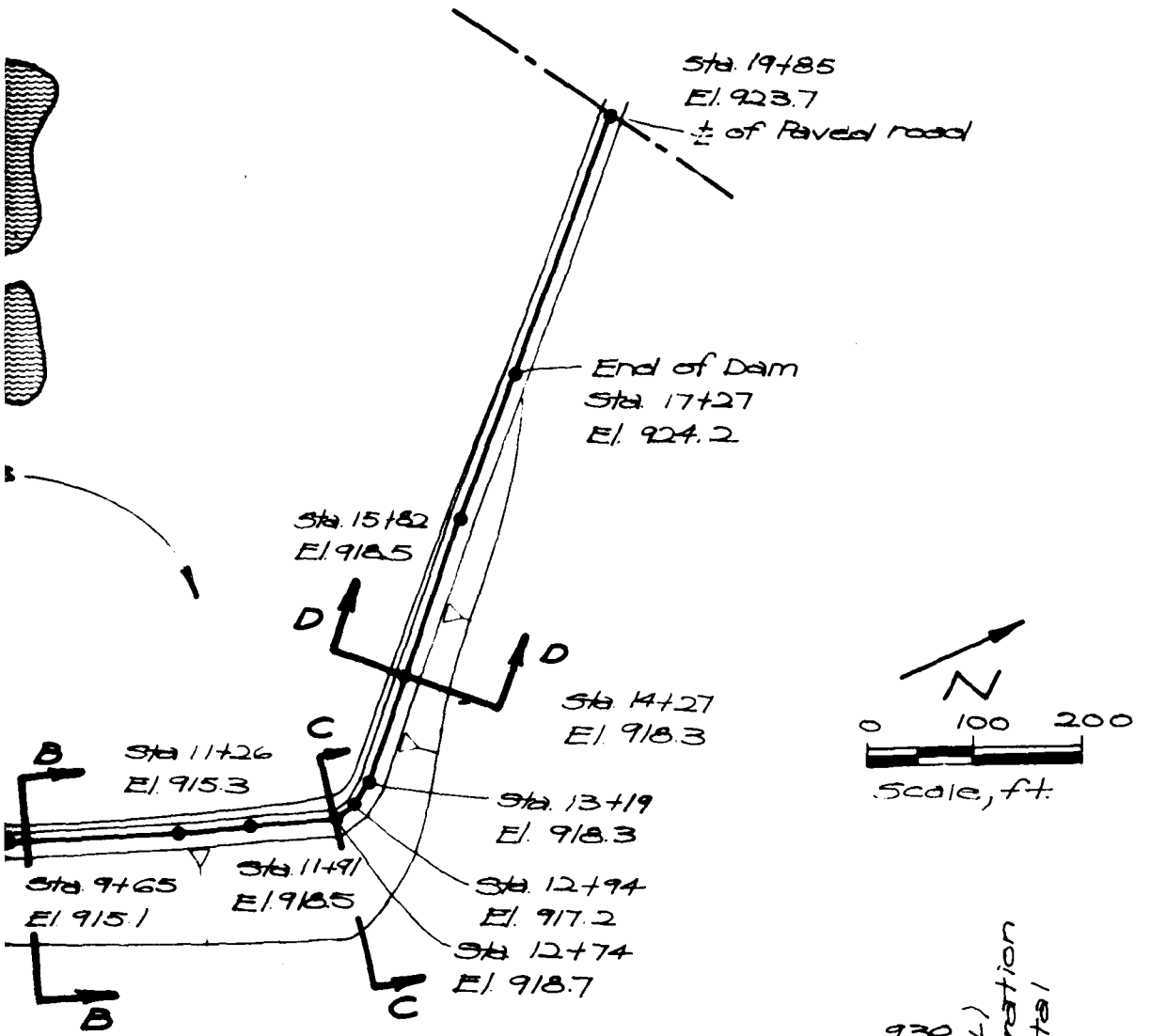
MO 31158 | Fig. 2

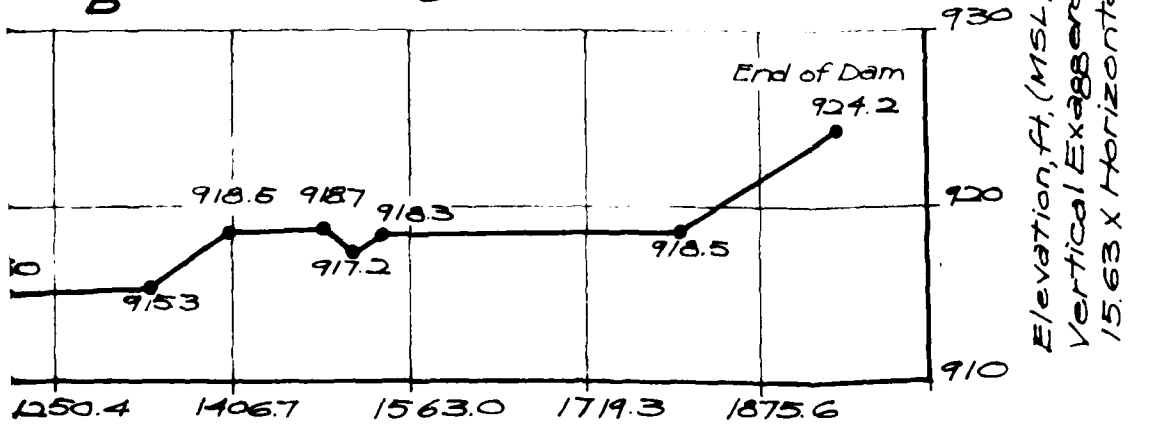


PLAN OF DAM



PROFILE OF DAM





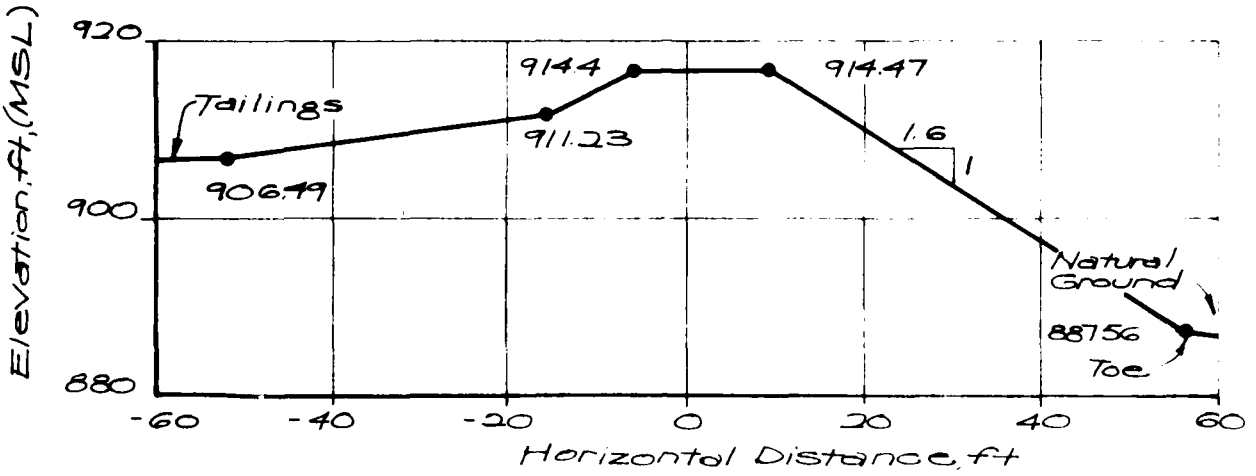
DAM

Note:
Survey data supplied by James F. McCaul III and Associates; Consulting Engineers / Land Surveyors. Potosi, Mo. 63664

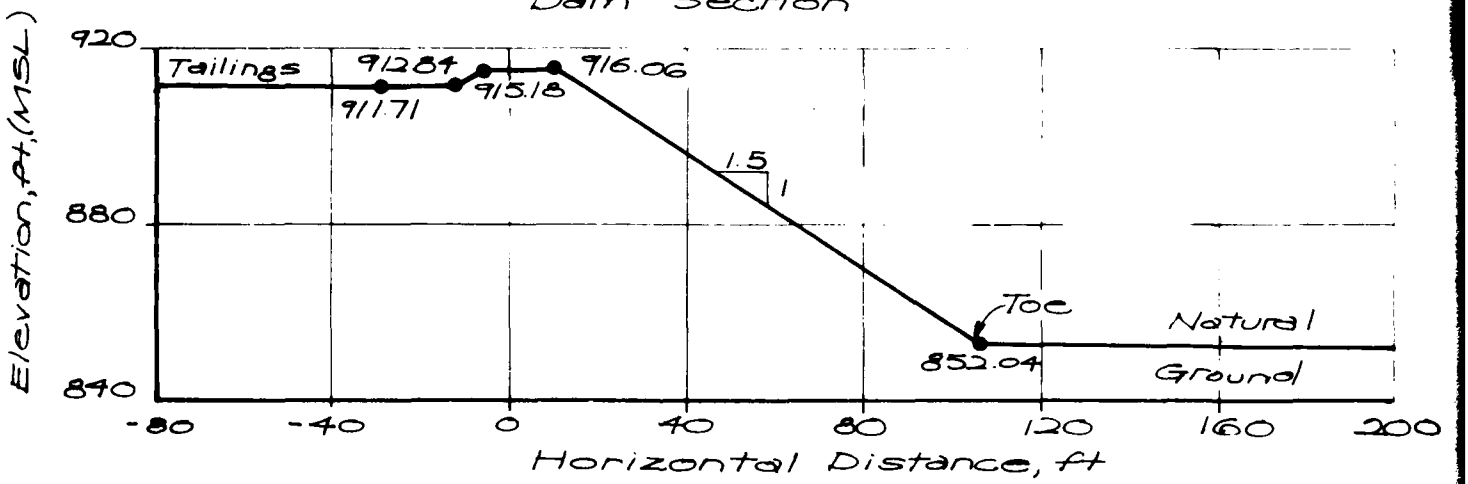
PLAN AND PROFILE OF DAM AND SPILLWAY

MINERAL POINT #2 DAM

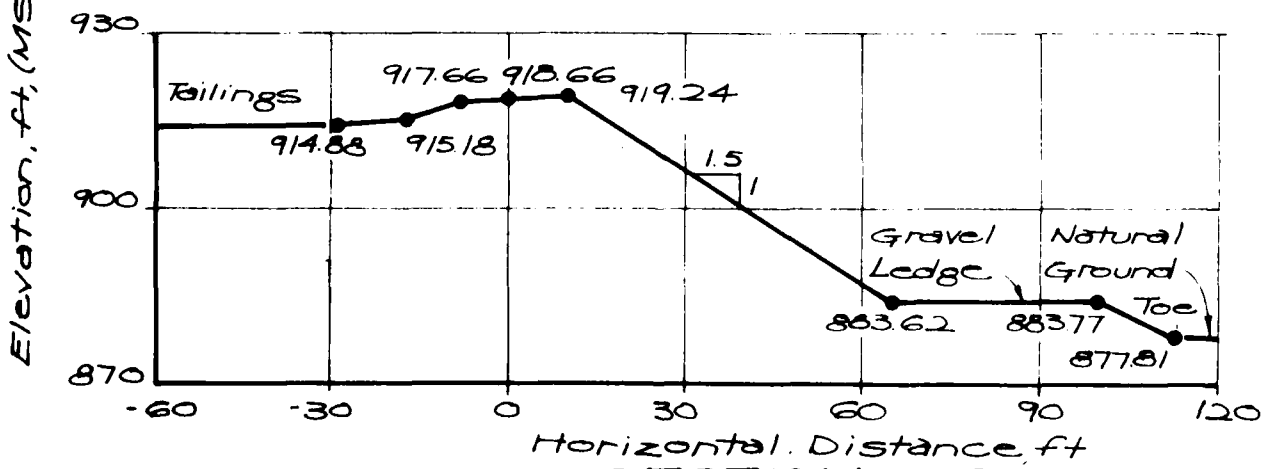
MO 31188 | Fig. 3-A



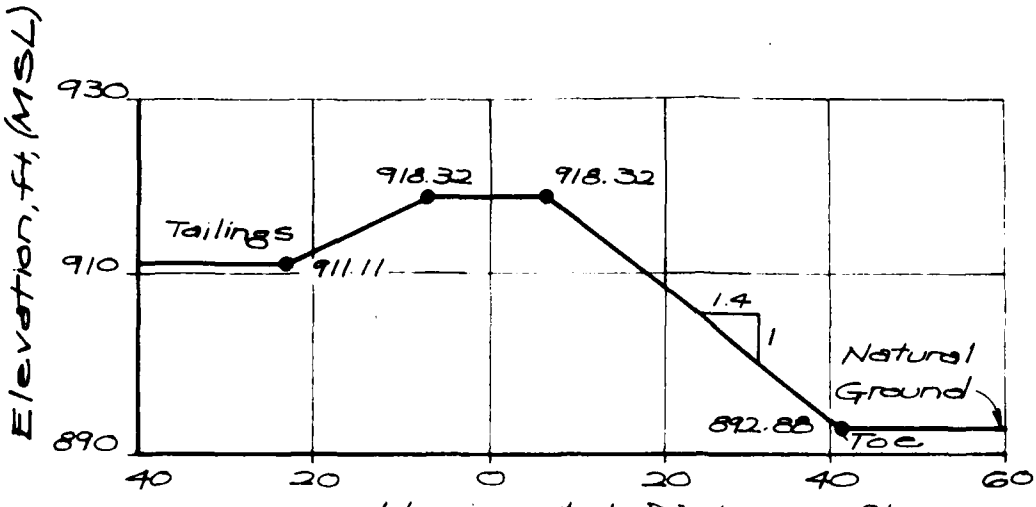
SECTION A-A
Dam Section



SECTION B-B
Maximum Dam Section



SECTION C-C
Dam Section



SECTION D-D
Dam Section

200

Note:
Survey data supplied by James F. McCaul III. and Associates; consulting Engineers/ Land Surveyors Potosi, Mo. 63664

SECTIONS OF DAM	
MINERAL POINT #2 DAM	
MO 31158	Fig. 3-B

Legend

- Or — Roubidoux Formation
- Gasconade Dolomite
  - Gunter Sandstone Member
- Cep — Eminence Dolomite
- Potosi Dolomite
- Derby-Doerun Dolomite
- Ceb — Davis Formation
- Bonneterre Formation
  - Whetstone Creek Member
  - Sullivan Siltstone Member
- Reagan Sandstone (subsurface, western Missouri)
- Lamotte Sandstone
- Diabase (dikes and sills)
- St. Francois Mountains Intrusive Suite
- St. Francois Mountains Volcanic Supergroup

REGIONAL GEOLOGIC MAP

MINERAL POINT #2 DAM

MO 31158 | **Fig. 4**

APPENDIX A

Photographs

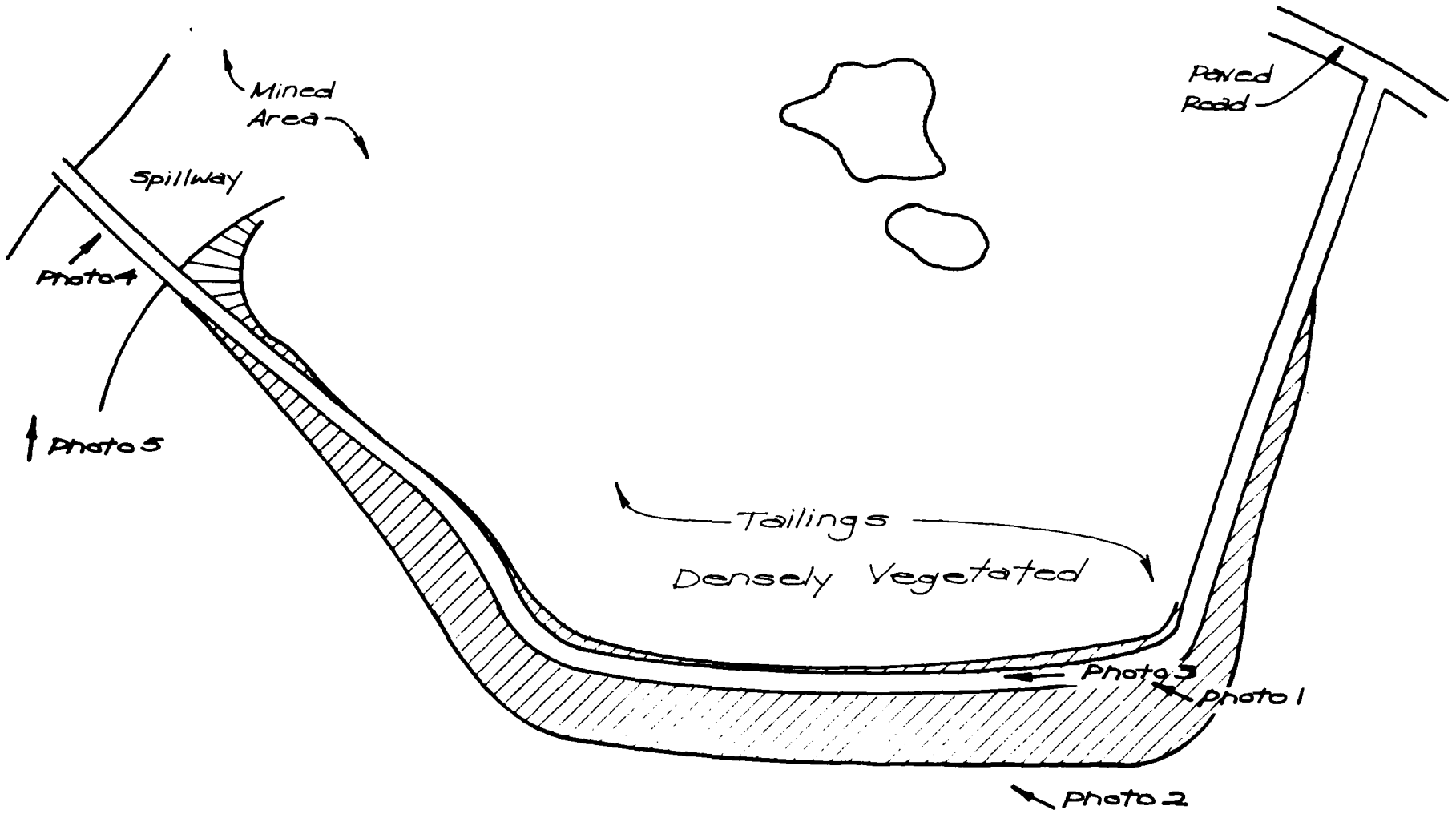
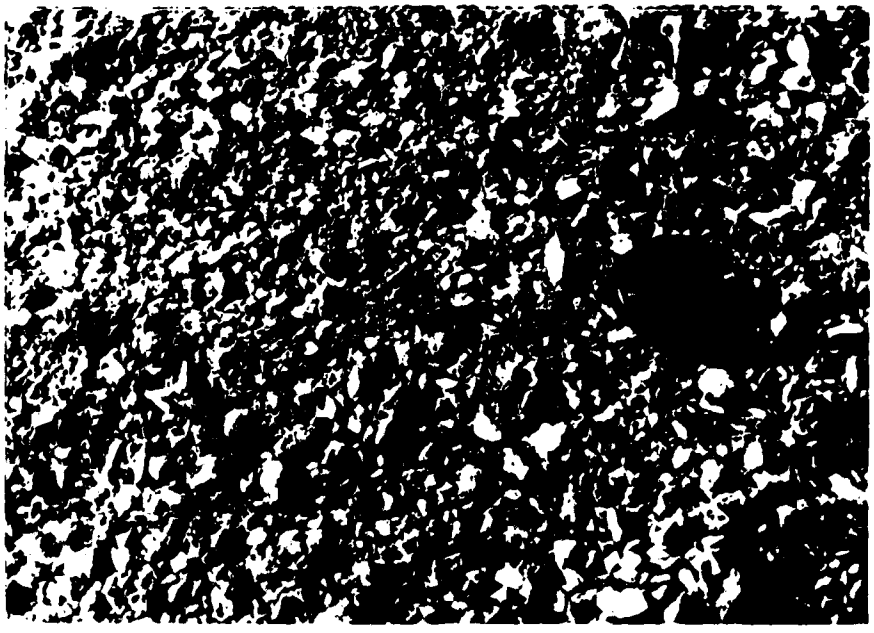


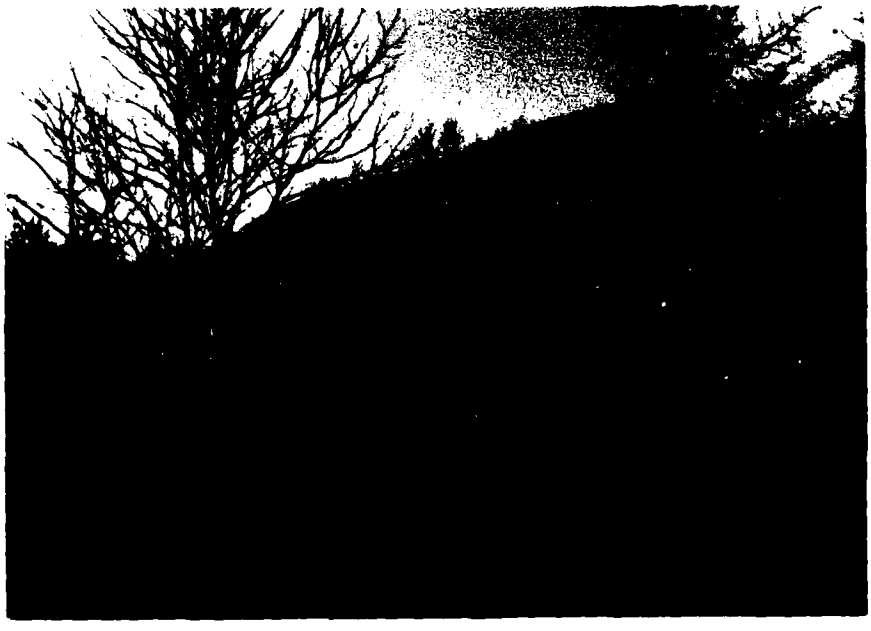
PHOTO LOCATION SKETCH

MINERAL POINT #2 DAM

MO 31158 | Fig. A-1



1. Close-up view of coarse tailings or "chat" used in embankment construction.



2. Downstream slope of Mineral Point #2 Dam. Looking southwest at maximum section. Note the irregular or "wavy" shape of the slope surface. Also note the tree on the upper right part of the photograph.

3. View of the crest of Mineral Point #2 Dam near the maximum section. Looking south. Note the irregular or "wavy" shape of the crest.

4. View of the spillway looking upstream from the head of the discharge channel. Dam is out of the photograph, on the right. Note the irregular topography upstream of the spillway and the vegetation.

5. View of the discharge channel looking upstream. Dam is out of the photograph, on the right.

APPENDIX B

Hydraulic/Hydrologic Data and Analyses

APPENDIX B
Hydraulic/Hydrologic Data and Analyses

B.1 Procedures

a. General. The hydraulic/hydrologic analyses were performed using the "HEC-1, Dam Safety Version (1 Apr 80)" computer program. The inflow hydrographs were developed for various precipitation events by applying them to a synthetic unit hydrograph. The inflow hydrographs were subsequently routed through the reservoir and appurtenant structures by the modified Puls reservoir routing option.

b. Precipitation events. The Probable Maximum Precipitation (PMP) and the 1 and 10 percent probability-of-occurrence events were used in the analyses. The total rainfall and corresponding distributions for the 1 and 10 percent probability events were provided by the St. Louis District, Corps of Engineers. The Probable Maximum Precipitation was determined from regional curves prepared by the US Weather Bureau (Hydrometeorological Report Number 33, 1956). The PMP distribution was computed by the HEC-1 program using the standard EM-1110-1411 method.

c. Unit hydrograph. The Soil Conservation Services (SCS) Dimensionless Unit Hydrograph method (SCS, 1971, Hydrology: National Engineering Handbook, Section 4) was used in the analysis. This method was selected because of its simplicity, applicability to drainage areas less than 10 mi^2, and its easy availability within the HEC-1 computer program.

The watershed lag time was computed using the SCS "curve number method" by an empirical relationship as follows:

$$L = \frac{\ell^{0.8}\,(s+1)^{0.7}}{1900\,Y^{0.5}} \qquad \text{(Equation 15-4)}$$

where: L = lag in hours
ℓ = hydraulic length of the watershed in feet = 1500
$s = \frac{1000}{CN} - 10 = 1.4$
CN = AMC II hydrologic soil curve number as indicated in Section B.2e.
Y = average watershed land slope in percent = 4.9.

This empirical relationship accounts for the soil cover, average watershed slope and hydraulic length.

With the lag time thus computed, another empirical relationship is used to compute the time of concentration as follows:

$$T_c = \frac{L}{0.6} \qquad \text{(Equation 15-3)}$$

where: T_c = time of concentration in hours

L = lag in hours.

Subsequent to the computation of the time of concentration, the unit hydrograph duration was approximated utilizing the following relationship:

$$\Delta D = 0.133 T_C \qquad \text{(Equation 16-12)}$$

where: ΔD = duration of unit excess rainfall
T_C = time of concentration in hours.

Due to the small lag time and 5 minute minimum duration internal constraint in the HEC-1 program, the requirement of a minimum three ordinates prior to the maximum could not be met. For this dam, a unit hydrograph duration of 5 minutes was used.

d. Infiltration losses. The infiltration losses were computed by the HEC-1 computer program internally using the SCS loss function. The curve number of SCS loss rate procedure was established taking into consideration the variables of: (a) antecedent moisture condition, (b) hydrologic soil group classification, (c) vegetative cover and (d) present land usage in the watershed. In addition, the computed basin loss was reduced proportional to the impervious area in the drainage basin.

Antecedent moisture condition III (AMC III) was used for the PMF events and AMC II was used for the 1 and 10 percent probability events, in accordance with the guidelines. The remaining variables are defined in the SCS procedure and judgements in their selection were made on the basis of visual field inspection.

e. Starting elevations. Reservoir starting water surface elevations for this dam were set as follows:

(1) 1 and 10 percent probability events - observed water surface

(2) Probable Maximum Storm - dependent on antecedent conditions

f. Spillway rating curve. The HEC-2 computer program was used to compute the spillway rating curve using spillway cross sections and characteristics assuming critical depth over the spillway.

B.2 Pertinent Data

a. Drainage area.

b. Storm duration. A unit hydrograph was developed by the SCS method option of HEC-1 program. The design storm of 24 hours duration was divided into 5-minute intervals in order to develop the inflow hydrograph.

c. Lag time. 0.18 hrs

d. Hydrologic soil group. C & D

e. SCS curve numbers.

1. For PMF- AMC III - Curve Number 95
2. For 1 and 10 percent probability-of-occurrence events - AMC II - Curve Number 88

f. Storage. Elevation-area data were developed by planimetering areas at various elevation contours on the USGS Mineral Point 7.5-minute quadrangle map (1958). The data were entered on the $A and $E cards so that the HEC-1 program could compute storage volumes.

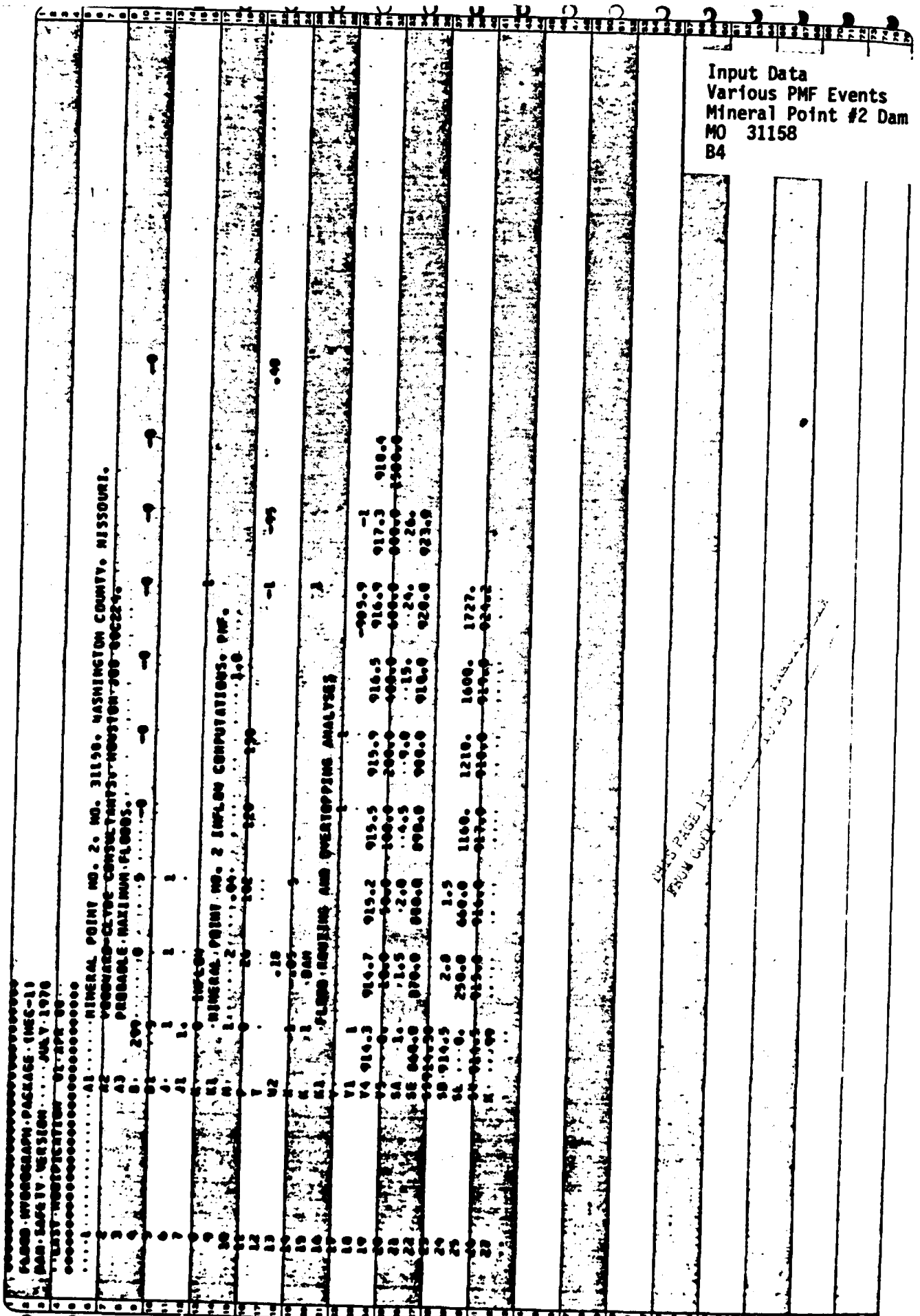
g. Outflow over dam crest. As the profile of the dam crest is irregular, flow over the crest was computed according to the "Flow Over Non-Level Dam Crest" supplement to the HEC-1 User's Manual. The crest length-elevation data and hydraulic constants were entered on the $D, $L, and $V cards.

h. Outflow capacity. The spillway rating curve was developed from the cross section data of the spillway using the HEC-2 backwater program. The results of the above were entered on the Y4 and Y5 cards of the HEC-1 program.

i. Reservoir elevations. For the 50 and 100 percent of the PMF events, the starting reservoir elevations were respectively 904.4 and 905.9 ft, determined by the antecedent storm conditions. For the 1 and 10 percent probability-of-occurrence events, the starting reservoir elevation was 902.8 ft, the elevation of the high water surface observed.

B.3 Results

The results of the analyses as well as the input values to the HEC-1 program follow in this Appendix. Only the results summaries are included, not the intermediate output. Complete copies of the HEC-1 output are available in the project files.



Input Data
Various PMF Events
Mineral Point #2 Dam
MO 31158
B4

```
HYDROLOGIC ENGINEERING METHODS
DAM SAFETY VERSION  JULY 1978
EASY MODIFICATION  01 APR 80
RUN DATED 23 MAR 81
RUN TIME 14:14:09

MINERAL POINT NO. 2, NO. 31158, WASHINGTON COUNTY, MISSOURI.
WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 80C224.
PROBABLE MAXIMUM FLOODS.

JOB SPECIFICATION
 NQ   NMR   NMIN   IDAY   IHR   IRIN   METRC   IPLT   IPRT   NSTAN
200     0      5     -0    -0     -0      -0     -0     -0      -0
                  JOPER   NWT   LROPT   TRACE
                     5     -0     -0      -0

MULTI-PLAN ANALYSES TO BE PERFORMED
  NPLAN= 1  MRTIO= 1  LRTIO= 1
 RTIO1=  1.000

SUB-AREA RUNOFF COMPUTATION
MINERAL POINT NO. 2 INFLOW COMPUTATIONS, PMF.
 ISTAQ   ICOMP   IECON   ITAPE   JPLT   JPRT   INAME   ISTAGE   IAUTO
INFLOW      0      -0      -0     -0     -0       1      -0      -0

HYDROGRAPH DATA
 IHYDR   IUNG   TAREA   SNAP   TRSDA   TRSPC   RATIO   ISHOW   ISAME   LOCAL
     1      2    .04      0.     .04    2.00      0.      -0      -0      -0

PRECIP DATA
 SPFE    PMS      R6      R12     R24     R48     R72     R96
   0.   26.00   102.00   120.00   130.00   -0.     -0.     -0.

LOSS DATA
 LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
    -0     -0.     -0.    1.00     -0.     -0.    1.00   -1.00  -95.00     -0.     .00
 CURVE NO =  -95.00  HETNESS =   -1.00  EFFECT CN =   95.00

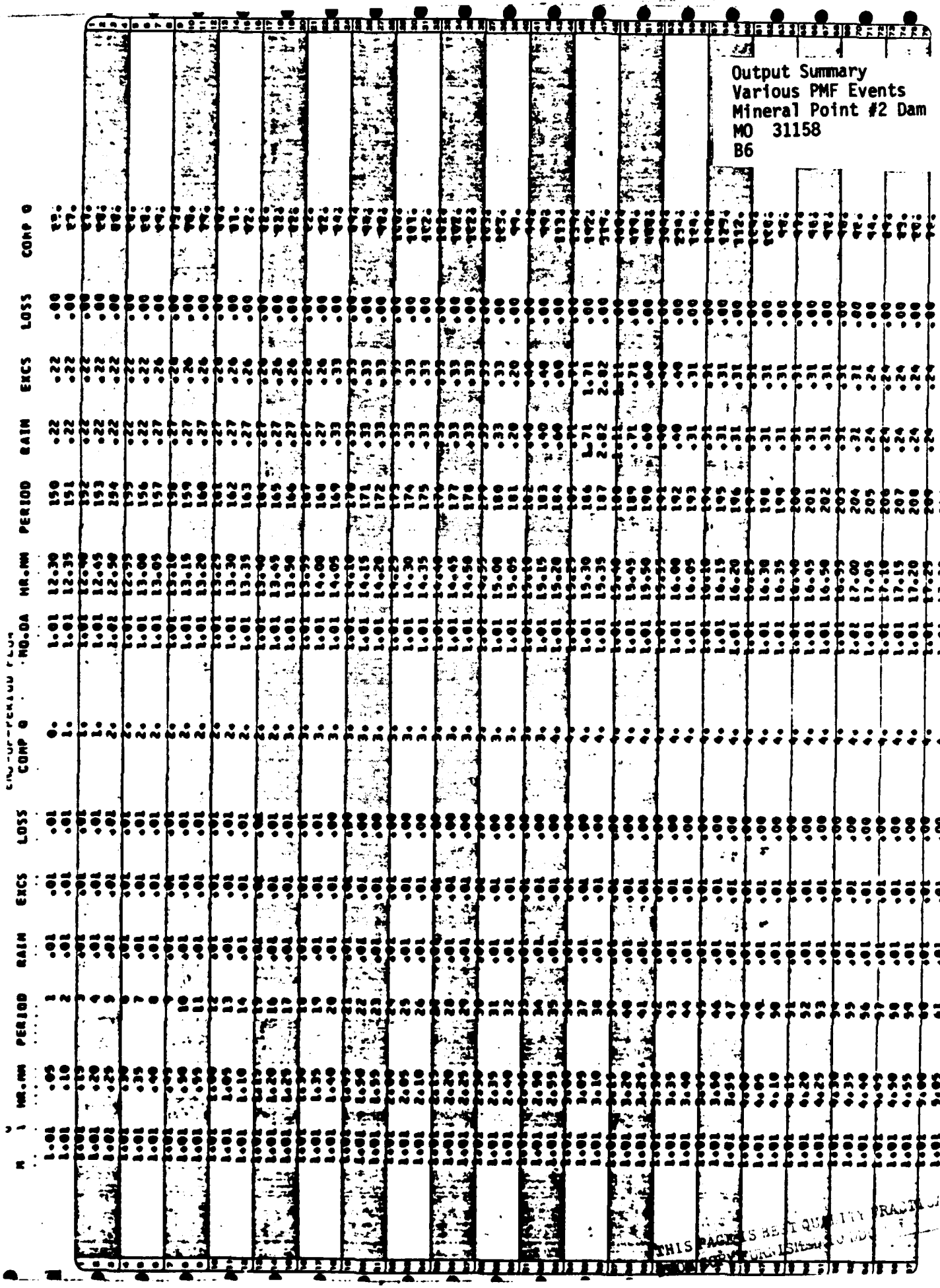
UNIT HYDROGRAPH DATA
 TC= -0.     LAG=  .18

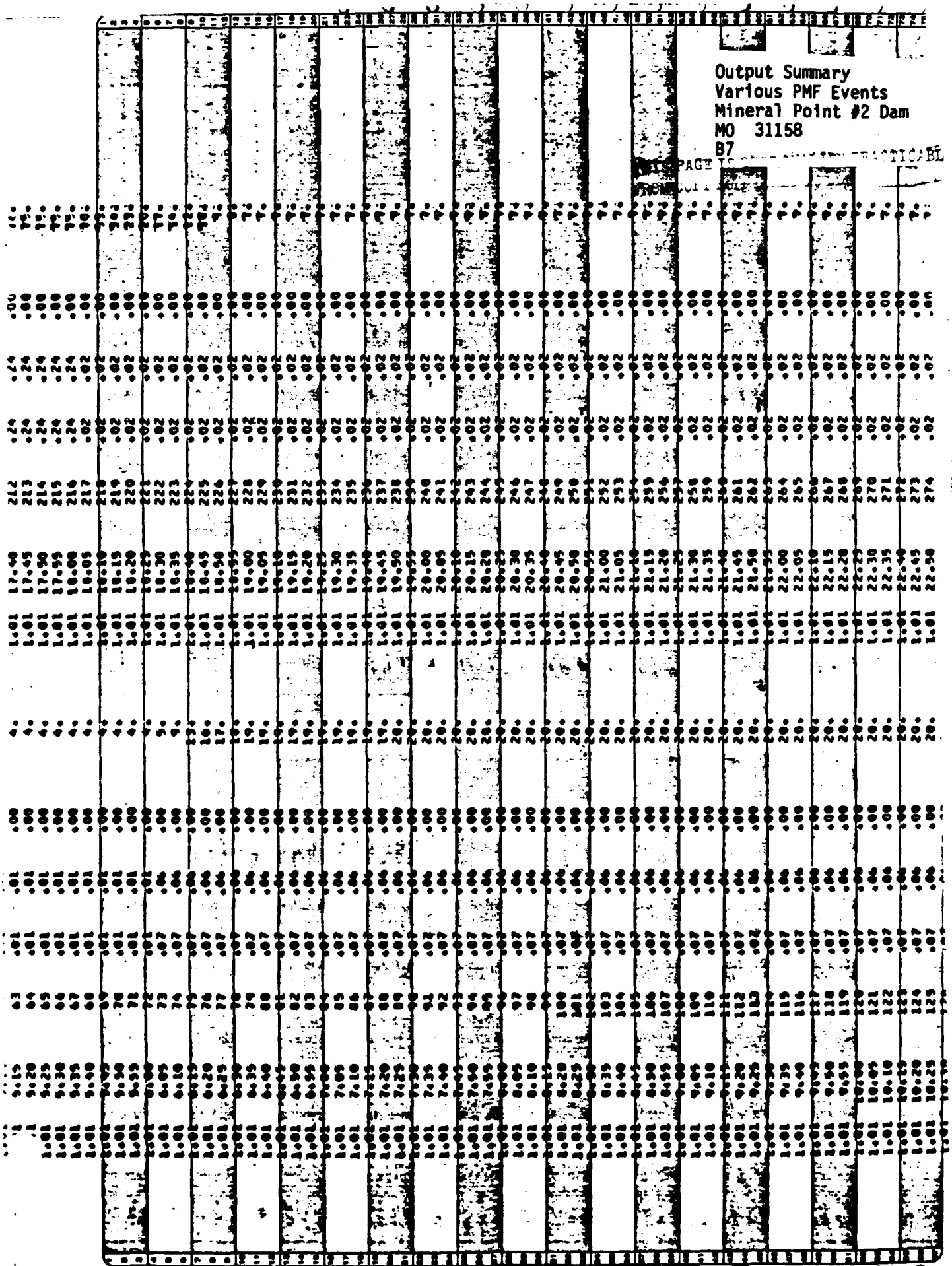
RECESSION DATA
 STRTQ=   -1.00    QRCSN=   -.05    RTIOR= 5.00

UNIT HYDROGRAPH 13 END-OF-PERIOD ORDINATES, TC=   -0.  HOURS, LAG=   .18  VOL= 1.00
  24.    76.    85.    59.    30.    17.     9.     5.     3.     1.
   1.     0.     0.

END-OF-PERIOD FLOW
```

Output Summary
Various PMF Events
Mineral Point #2 Dam
MO 31158
B6




Output Summary
Various PMF Events
Mineral Point #2 Dam
MO 31158
B7

Output Summary
Various PMF Events
Mineral Point #2 Da
MO 31158
B8

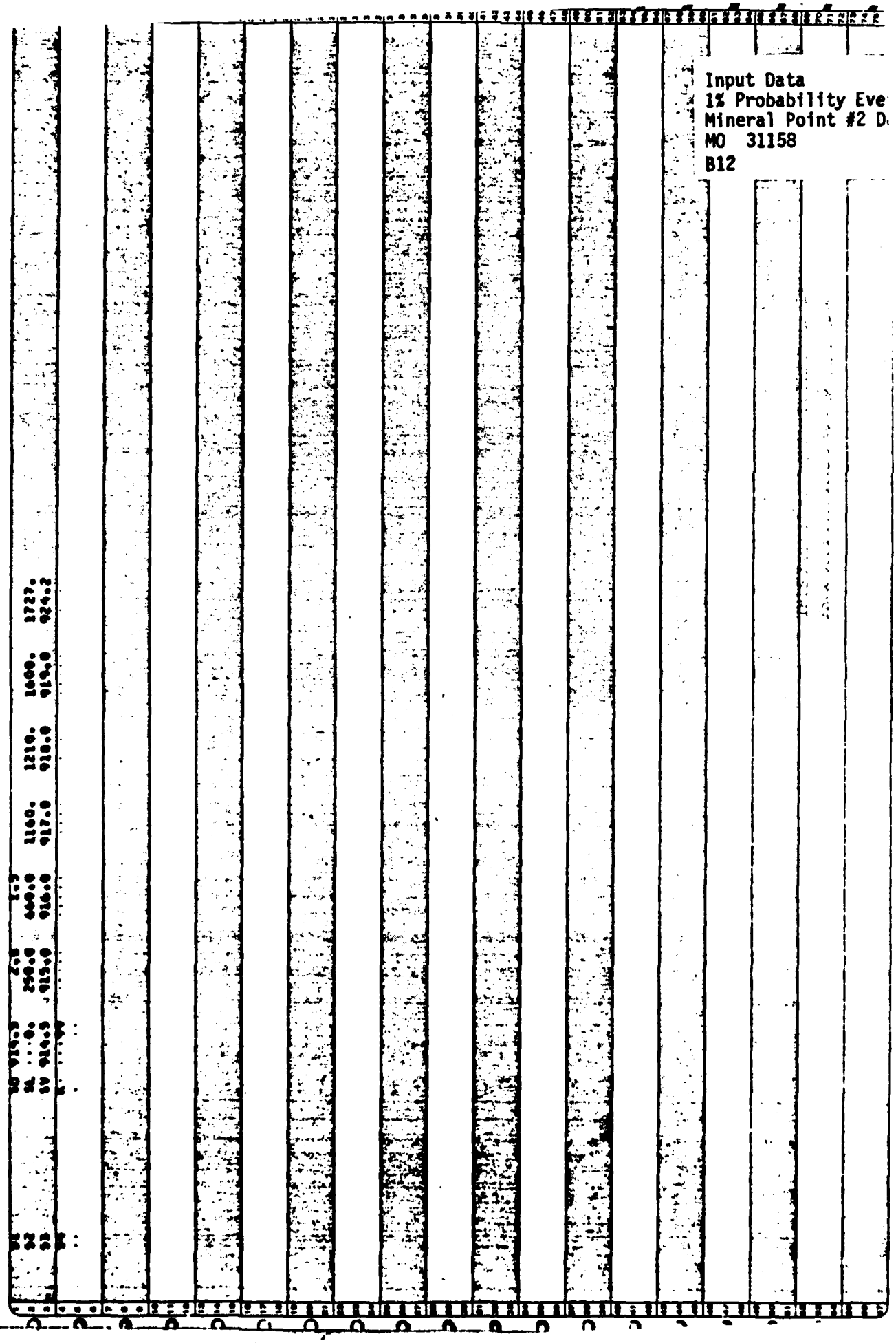
Output Summary
Various PMF Events
Mineral Point #2 De
MO 31158
B9

Output Summary
Various PMF Events
Mineral Point #2 Da
MO 31158
B10

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1									
		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM					
	ELEVATION	909.00	914.38	914.50					
	STORAGE	190.	319.	322.					
	OUTFLOW	0.	0.	0.					
RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS		
1.00	911.00	0.	202.	0.	0.	0.	0.		

Input Data
1% Probability Event
Mineral Point #2 Dam
MO 31158
B11


Input Data
1% Probability Eve
Mineral Point #2 D
MO 31158
B12

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FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION       JULY 1978
LAST MODIFICATION  01 APR 80
****************************************

RUN DATE* 81/03/23.
    TIME* 13.20.55.

                    MINERAL POINT NO. 2. MO. 31158. WASHINGTON COUNTY. MISSOURI.
                    WOODWARD-CLYDE CONSULTANTS. HOUSTON JOB 80C224.
                    PROBABILISTIC FLOOD -- 100 YEAR.

                                         JOB SPECIFICATION
             NQ      NHR     NMIN    IDAY     IHR    IMIN   METRC    IPLT    IPRT   NSTAN
            299        0        5       0       0       0       0       0       0       0
                                    JOPER     NWT   LROPT   TRACE
                                        3       0       0       0

      **********         **********        **********        **********        **********

                                  SUB-AREA RUNOFF COMPUTATION

                RAIN STA. 10-LESTERVILLE. FREQ= 1.0. INTERVAL=05.0 MIN.. DURATION=24 HRS.

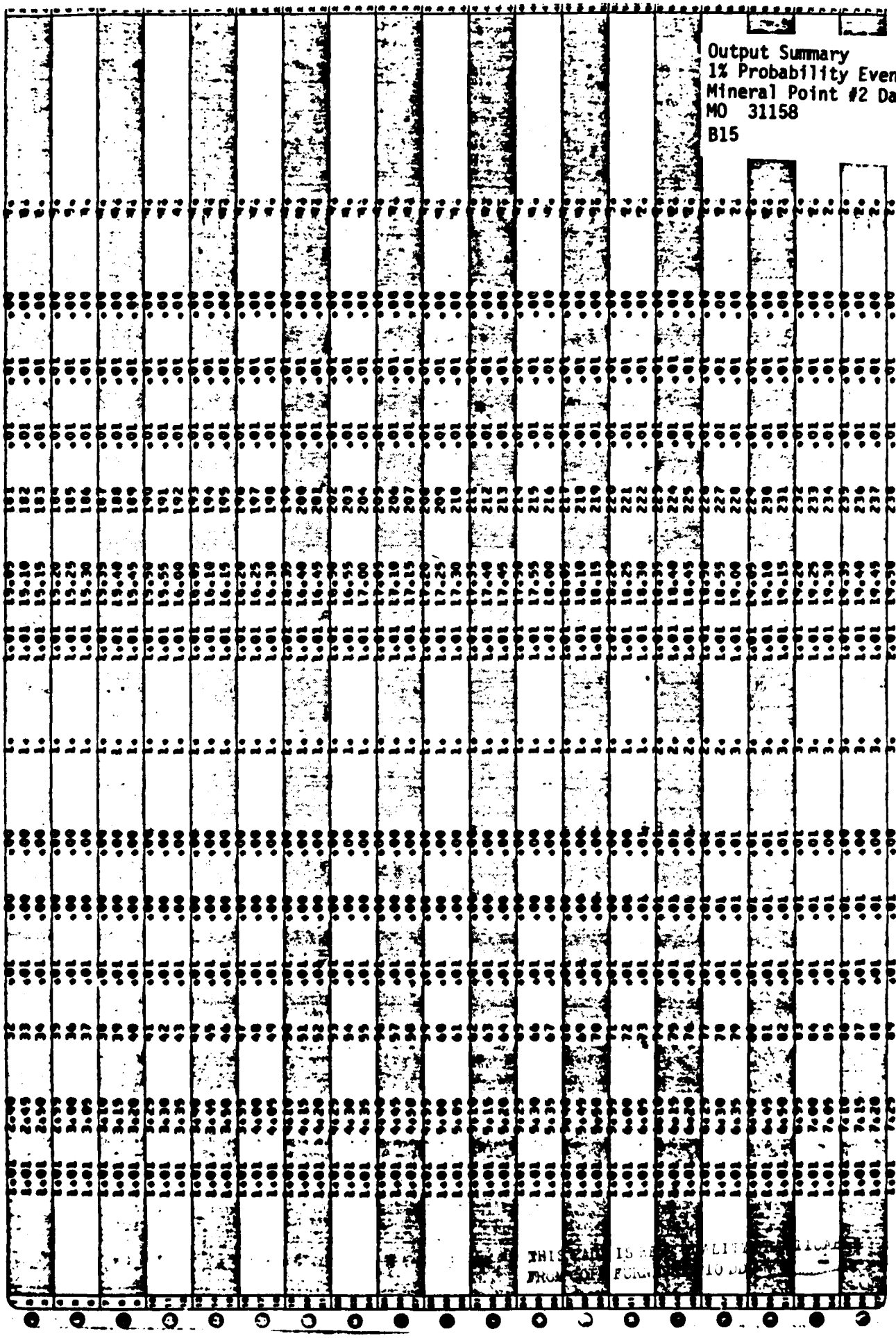
                      ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                      INFLOW      0       0       0       0       0       1       0       0

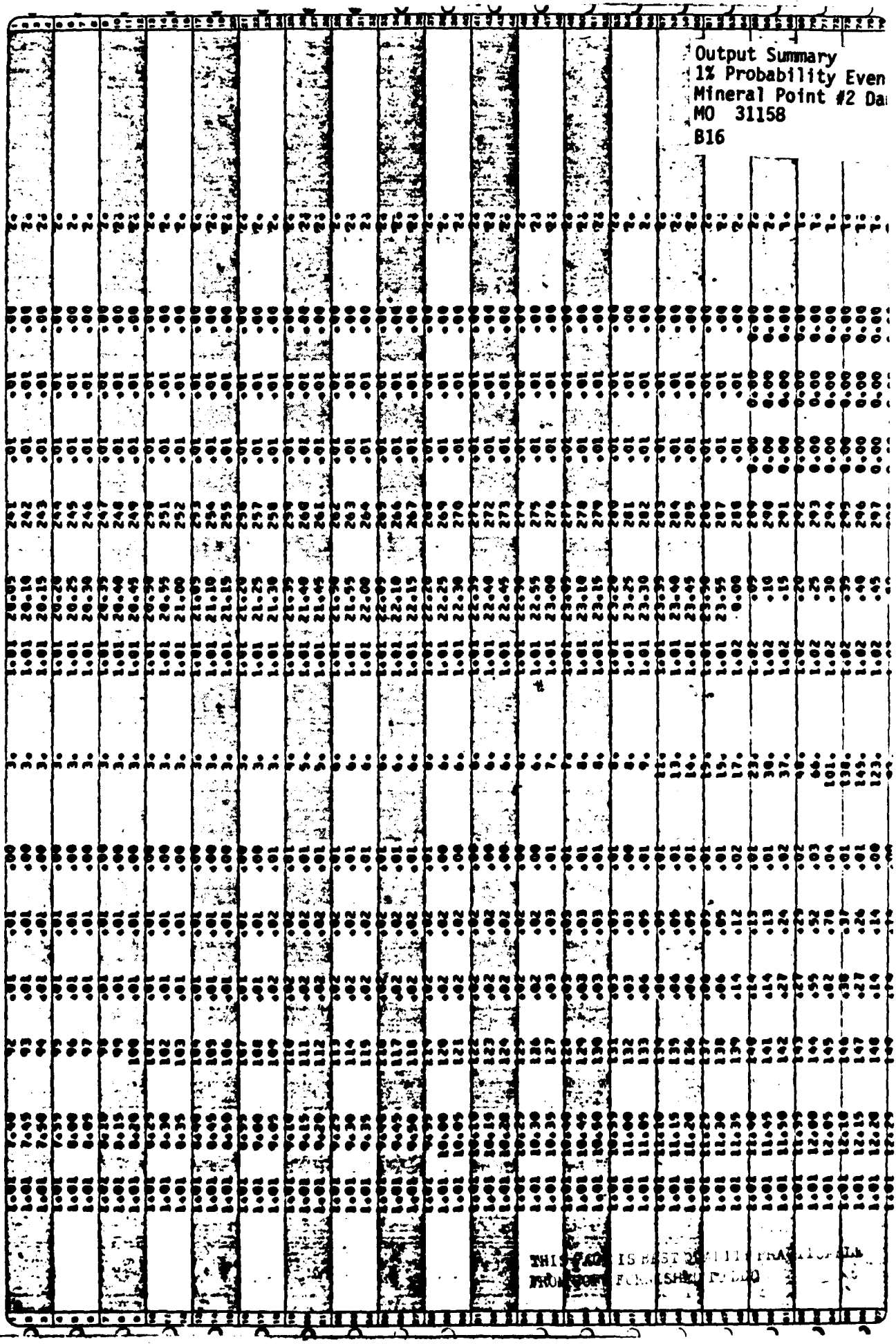
                                        HYDROGRAPH DATA
             IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
                 0       2     .04    0.00     .04    1.00   0.000       0       0       0

                                          PRECIP DATA
                               NP   STORM     DAJ     DAK
                              288    7.39    0.00    0.00
                                        PRECIP PATTERN
       .01     .01     .01     .01     .01     .01     .01     .01     .01     .01
       .01     .01     .01     .01     .01     .01     .01     .01     .01     .01
       .01     .01     .01     .01     .01     .01     .01     .01     .01     .01
       .01     .01     .01     .01     .01     .01     .01     .01     .01     .01
       .01     .01     .01     .01     .01     .01     .01     .01     .01     .01
       .01     .01     .01     .01     .01     .01     .01     .01     .01     .01
       .01     .01     .01     .01     .01     .01     .01     .01     .01     .01
       .01     .01     .01     .01     .01     .01     .01     .01     .01     .01
       .01     .01     .01     .01     .01     .01     .01     .01     .01     .01
       .01     .01     .01     .01     .01     .01     .01     .01     .01     .01
       .01     .01     .01     .01     .01     .01     .01     .01     .03     .03
       .03     .03     .03     .03     .03     .03     .03     .03     .03     .03
       .03     .03     .03     .03     .03     .03     .03     .03     .03     .03
       .03     .03     .06     .06     .06     .06     .06     .06     .14     .14
       .14     .27     .27     .55     .02     .30     .27     .14     .14     .14
       .06     .06     .06     .06     .06     .06     .03     .03     .03     .03
       .03     .03     .03     .03     .03     .03     .03     .03     .03     .03
       .03     .03     .03     .03     .03     .03     .03     .03     .03     .03
       .01     .01     .01     .01     .01     .01     .01     .01     .01     .01
       .01     .01     .01     .01     .01     .01     .01     .01     .01     .01
```

Output Summary
1% Probability Eve
Mineral Point #2 D
MO 31158
B13

.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	


Output Summary
1% Probability Event
Mineral Point #2 Dam
MO 31158
B15



		PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME	
	CFS	149.	21.	7.	7.	2032.	
	CMS	4.	1.	0.	0.	58.	
	INCHES		0.99	0.94	0.94	0.94	
	MM		120.66	166.20	166.68	166.68	
	AC-FT		11.	14.	14.	14.	
	THOUS CU M		13.	17.	17.	17.	

HYDROGRAPH ROUTING

FLOOD ROUTING AND OVERTOPPING ANALYSES

ISTAO	ICONP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
DAM	1	0	0	0	0	1	0	0

ROUTING DATA

CLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP		LSTR
0.0	0.000	0.00	1	0	0	0		8

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-903.	-1

ELEV	914.00	914.20	914.40	914.60	914.80	915.00	915.20	915.40	915.60
FLOW	0.00	10.00	50.00	100.00	200.00	400.00	600.00	800.00	1000.00
SURFACE AREA=	1.	2.	2.	5.	9.	15.	24.	26.	
CAPACITY=	0.	12.	30.	62.	120.	246.	440.	519.	
ELEVATION=	860.	870.	880.	890.	900.	910.	920.	921.	

CREL	SPWID	COQW	EXPW	ELEVL	COOL	CAREA	EXPL
914.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
914.9	2.6	1.5	0.

CREST LENGTH	0.	290.	660.	1160.	1210.	1600.	1727.
AT OR BELOW ELEVATION	914.9	915.0	916.0	917.0	918.0	919.0	924.2

END-OF-PERIOD HYDROGRAPH ORDINATES

HR.DA	HR.MN	PERIOD	HOURS	INFLOW	OUTFLOW	STORAGE	STAGE
1.01	.05	1	.08	0.	0.	155.	902.0
1.01	.10	2	.17	0.	0.	155.	902.0

1% Probability Eve Output Summary
Mineral Point #2 D
MO 31158
B17

Output Summary
1% Probability Even
Mineral Point #2 Da
MO 31158
B18

Output Summary
1% Probability Even
Mineral Point #2 Da
MO 31158
B19

SUMMARY OF DAM SAFETY ANALYSIS

PLAN	RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
		INITIAL VALUE						
		ELEVATION	902.00		914.30	914.50		
		STORAGE	155.		319.	322.		
		OUTFLOW	0.		0.	0.		
	1.00	906.88	0.00	169.	0.	0.00	0.00	0.00

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